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(54) **FILTER ASSEMBLY FOR A FUEL INJECTOR**

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(Continued)

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(57) **ABSTRACT**

A filter assembly for a fuel injector. In some embodiments, the filter assembly has a longitudinal axis and comprises a filter element, a filter housing, and a cap. The filter element may have a cylindrical section with a first axial end and a second axial end. The tubular filter housing may receive the filter element. The tubular filter housing may include a radial protrusion supporting the first axial end of the cylindrical section when the filter element is received therein. The cap may hold the filter element at the second axial end and encompass the filter housing along an outer circumference. The second axial end may rest directly against the cap.

15 Claims, 4 Drawing Sheets

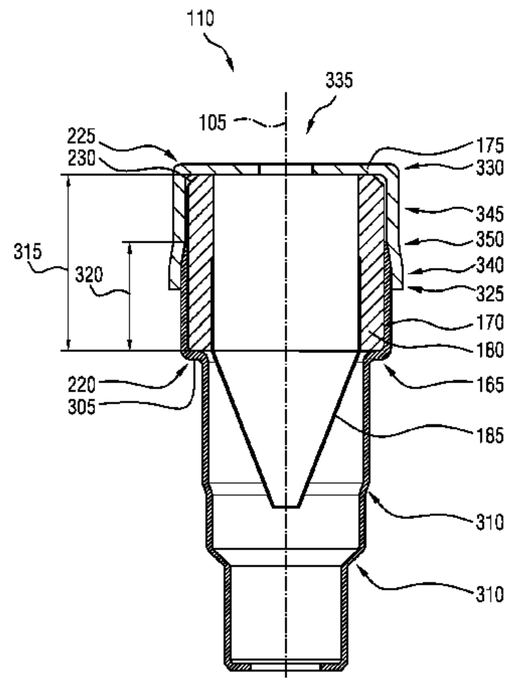

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FIG 1

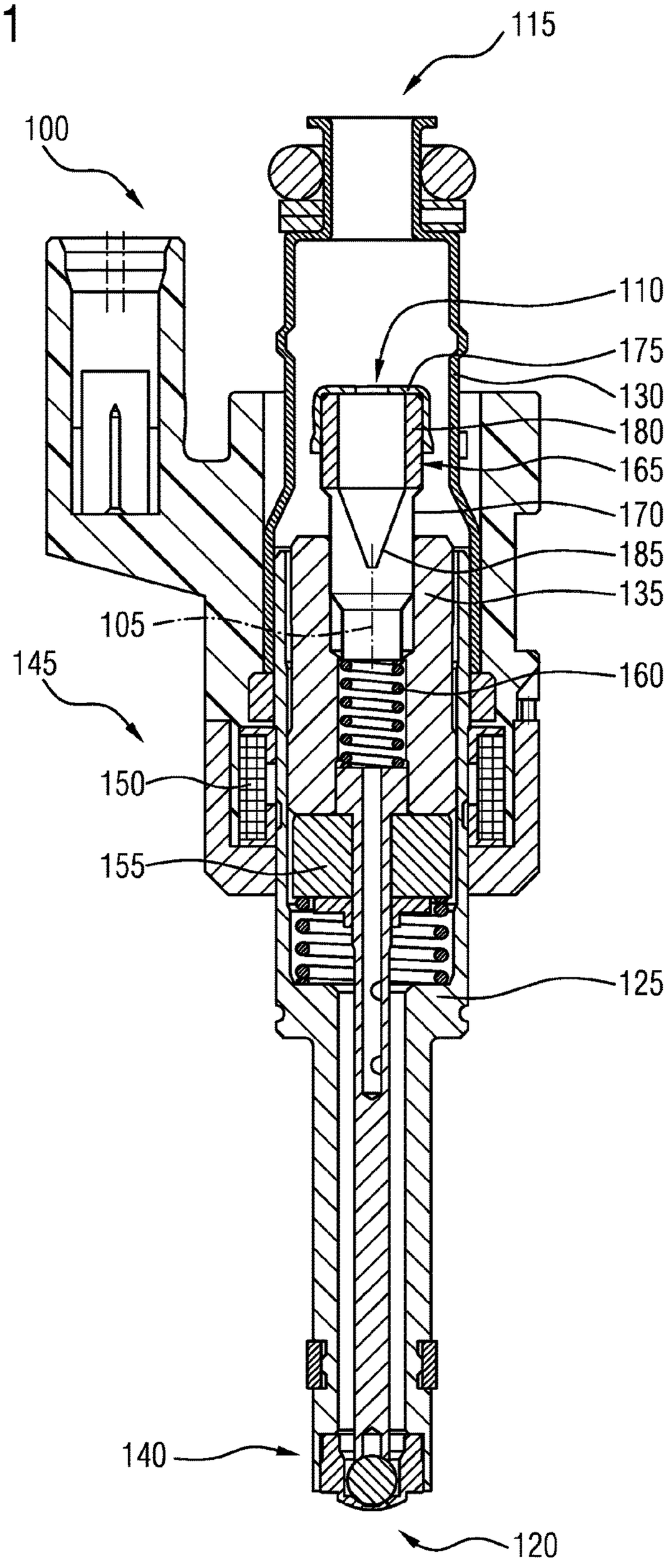

115
100
110
175
130
180
165
170
185
135
105
145
160
150
155
125
140
120

FIG 2

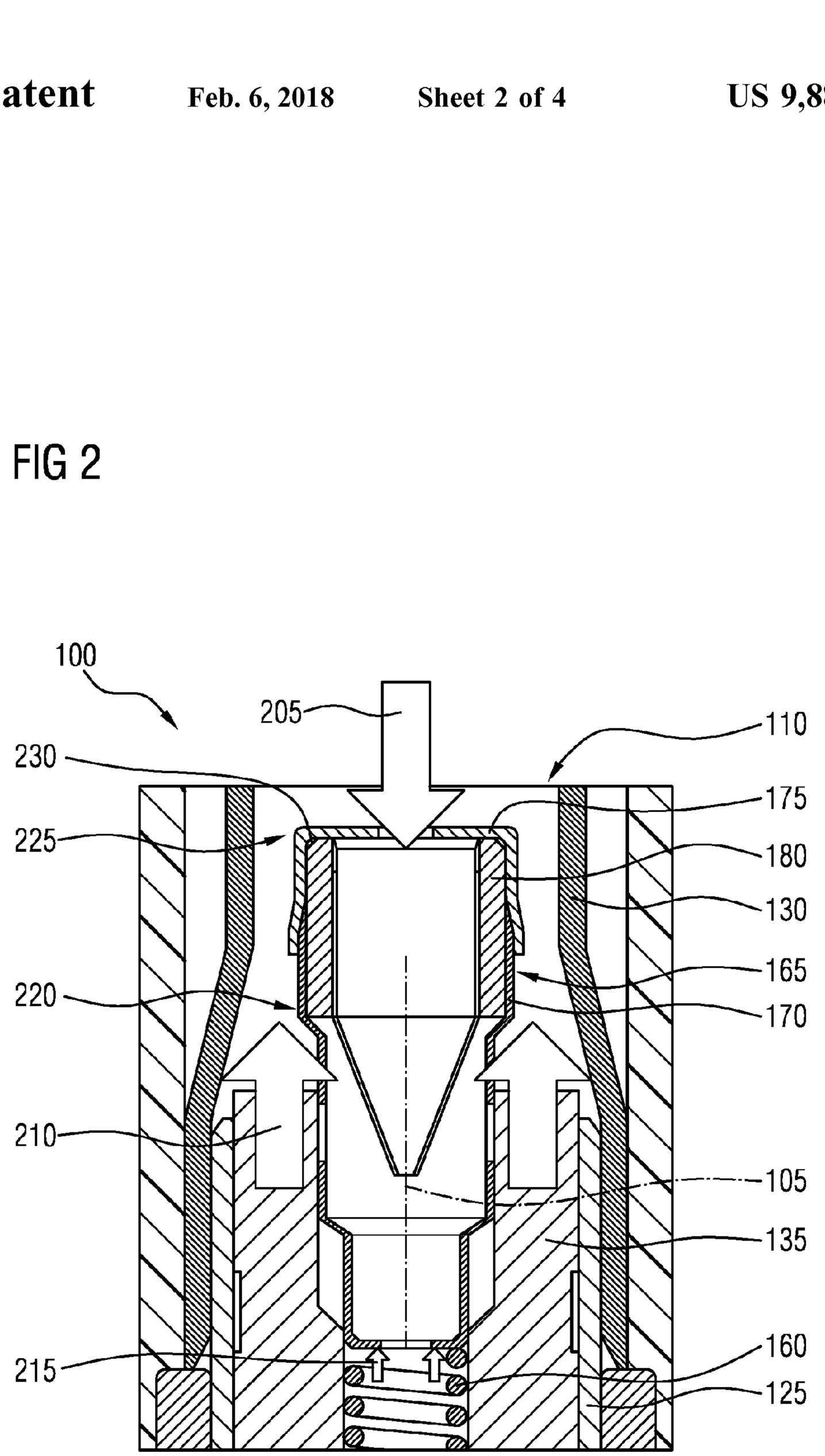
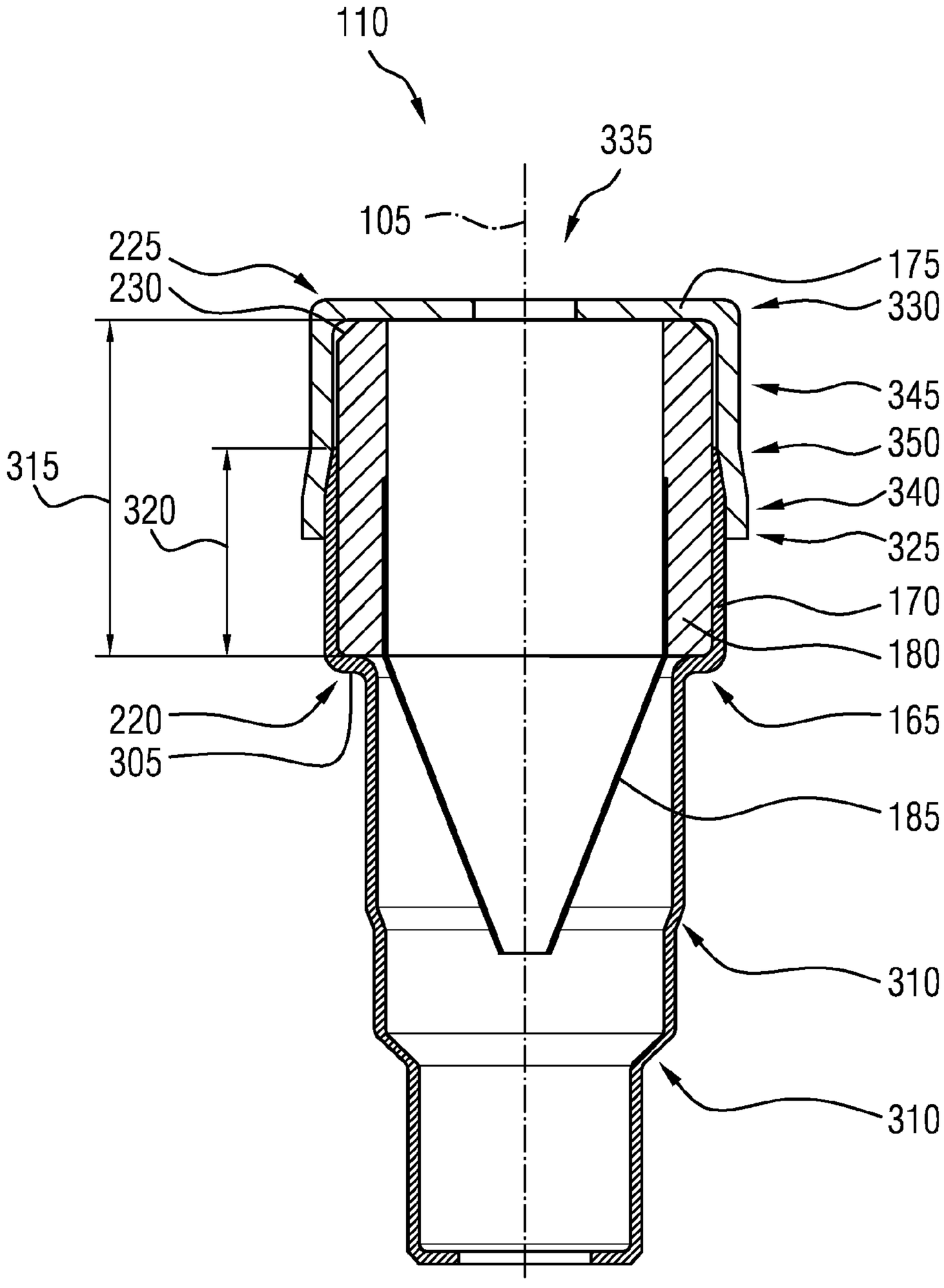

100
205
110
230
175
225
180
130
165
220
170
210
105
135
160
215
125

FIG 3


110
335
105
225
230
175
330
345
350
340
325
315
320
170
180
165
220
305
185
310
310

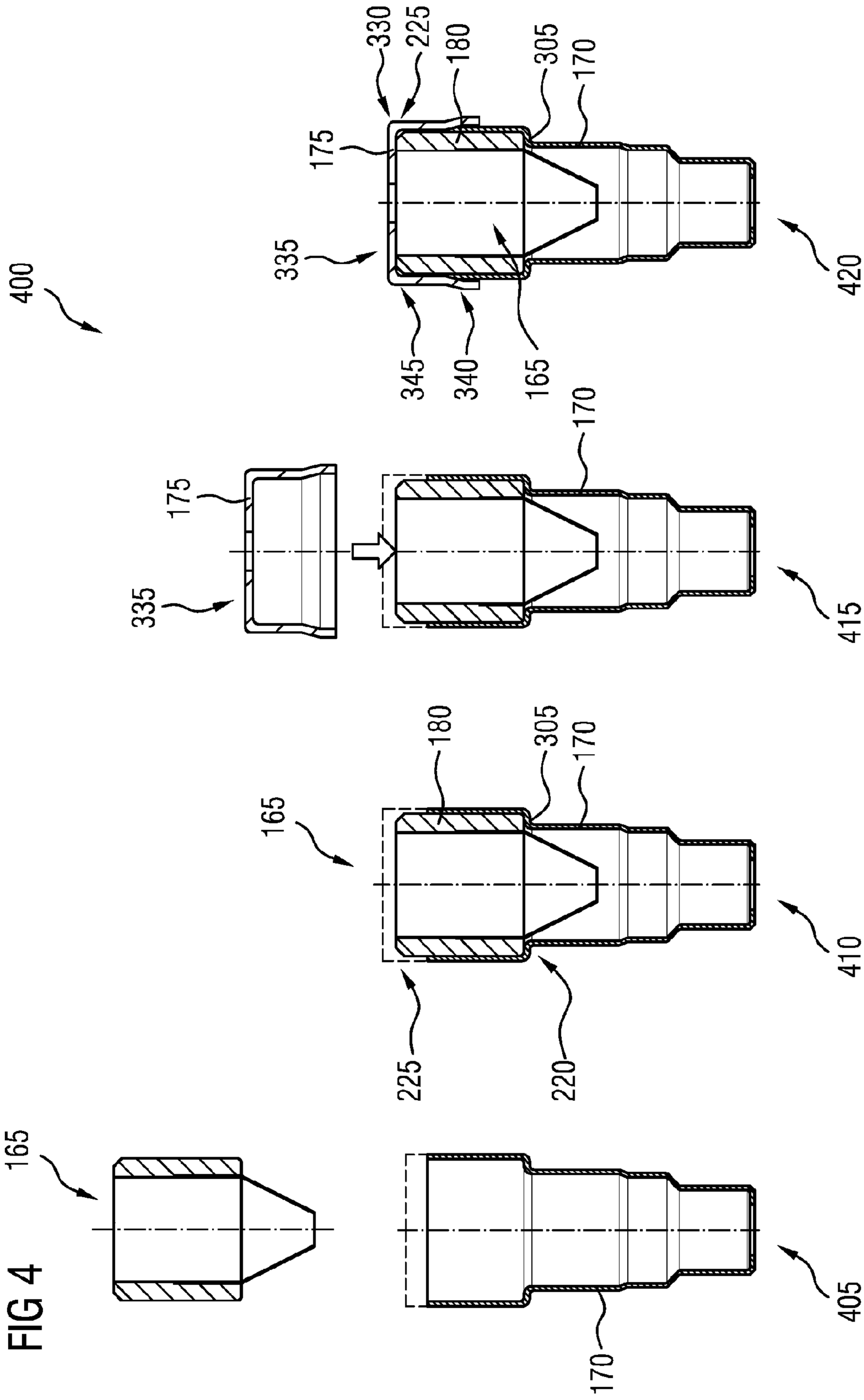

400
330
225
180
305
170
175
335
420
345
340
165
170
175
335
415
180
305
170
165
410
225
220
165
170
405

FIG 4

FILTER ASSEMBLY FOR A FUEL INJECTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. National Stage Application of International Application No. PCT/EP2015/050475 filed Jan. 13, 2015, which designates the United States of America, and claims priority to EP Application No. 14151429.9 filed Jan. 16, 2014, the contents of which are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

The present disclosure concerns a filter assembly for a fuel injector. More specifically, the present invention concerns a filter assembly, a fuel injector, and a method for assembling the filter assembly.

BACKGROUND

A combustion engine, especially of the piston type, may use a fuel injector for injecting fuel into a combustion chamber. The fuel injector comprises a filter assembly that is commonly press-fitted into the injector in an axial direction during manufacturing the injector.

EP 1 229 239 A2 shows a fuel injector with such a filter. The filter assembly comprises a filter element and a tubular filter housing for receiving the filter element. The filter element has a side wall with a shoulder for supporting an axial end of the filter element on the filter housing.

As the filter assembly is press-fitted into the injector, considerable axial forces may act against the side wall in a region of the shoulder. The filter element may deform temporarily or permanently so that the position of an upper section of the filter assembly with respect to the injector may be poorly defined. In addition, considerable tension may occur between the shoulder and the axial end of the filter element. This may lead to a rupture of the filter element so that unfiltered fuel may pass towards the delicate valve system of the injector.

SUMMARY

It is an object of the present disclosure to describe a filter assembly, a fuel injector, and a method for assembling the filter assembly that resists deformation of the filter assembly during assembly or installation in the fuel injector.

Some embodiments may include a filter assembly (**110**) for an injector (**100**) for injecting fuel into a combustion engine. The filter assembly (**110**) may have a longitudinal axis (**105**) and comprise: a filter element (**165**) with a cylindrical section (**180**) having a first axial end (**220**) and a second axial end (**225**); a tubular filter housing (**170**) in which the filter element (**165**) is received; and a cap (**175**) for holding the filter element (**165**) at the second axial end (**225**). The filter housing (**170**) may have a radial protrusion (**305**) which supports the first axial end (**220**) of the cylindrical section (**180**). The cap (**175**) may encompass the filter housing (**170**) along an outer circumference. The second axial end (**225**) may rest directly against the cap (**175**).

In some embodiments, the cylindrical section (**180**) is provided with a chamfer (**230**) at its second axial end **255** and/or the cylindrical section (**180**) extends radially inwards further than the shoulder (**305**) of the filter housing (**170**).

In some embodiments, the filter element (**165**) comprises a filter screen (**185**) which is fixed to the cylindrical section (**180**) and wherein the cylindrical section (**180**) comprises or consists of a plastic material.

In some embodiments, the filter housing (**170**) and the cap (**175**) comprise a metal or an alloy or consist thereof.

In some embodiments, an axial length (**320**) of the filter housing between the protrusion (**305**) and the cap (**175**) is smaller than the axial length (**315**) of the cylindrical section (**180**) of the filter element (**165**).

In some embodiments, an inner diameter of the cap (**175**) is aligned with an outer diameter of the filter housing (**170**) such that the cap (**175**) is in force-fit engagement with the filter housing (**170**) with a predetermined frictional force.

In some embodiments, the filter cap (**175**) has an open end (**325**) which axially overlaps the filter housing (**170**) and a partially closed opposite end **330** which is positioned subsequent to the cylindrical section (**180**) in axial direction from the first axial end (**220**) towards the second axial end (**225**) and wherein the filter cap (**175**) comprises a first axial section (**340**) near the open end (**325**) and a second axial section (**345**) near the opposite end (**330**) and a taper (**350**) is located between said first and second axial sections (**340**, **345**) such that an inner diameter of the second section (**345**) is smaller than an inner diameter of the first section (**340**).

In some embodiments, the inner diameter of the second section (**345**) is aligned with an outer diameter of the cylindrical section (**180**) of the filter element (**165**) such that the filter element (**165**) rests laterally against the second section (**345**).

In some embodiments, the filter assembly (**110**) is configured to be axially press-fitted with another component of the injector (**100**) by means of the filter housing (**170**).

In some embodiments, a fuel injector (**100**) includes a filter assembly (**110**) as taught above. The fuel injector may further comprise a body (**125**) which is a hollow valve body of the fuel injector (**100**) and a block (**135**) which is a pole piece of an electromagnetic actuator (**145**) of the fuel injector (**100**), wherein the filter assembly (**110**) is kept in its position in the fuel injector (**100**) by friction between the block (**135**) and the filter housing (**170**).

In some embodiments, the fuel injector may additionally comprise a valve needle and a calibration spring (**160**) for biasing the valve needle towards a closing position, wherein the filter housing (**170**) comprises a spring seat for the calibration spring (**160**) at its axial end remote from the cap (**175**).

Assembling a filter assembly (**110**) may include the following steps: inserting (**405**) the filter element (**165**) axially into the filter housing (**170**); and axially pressing (**415**) the cap (**175**) onto the filter housing (**170**) until the second axial end (**225**) of the cylindrical section (**180**) makes contact with the cap (**175**).

In some embodiments, the pressing is continued (**420**) until a predetermined pressing force is reached, the predetermined force exceeding a frictional force between the filter cap (**175**) and the filter housing (**170**).

BRIEF DESCRIPTION OF THE DRAWINGS

An exemplary embodiment of the invention will now be described in more detail with reference to the enclosed figures in which:

FIG. **1** shows a fuel injector in a longitudinal section view, according to teachings of the present disclosure;

FIG. **2** shows a filter assembly being installed in the fuel injector of FIG. **1** in a longitudinal section view;

FIG. **3** shows the filter assembly according to FIG. **1** or **2** in a longitudinal section view, and

FIG. **4** shows different stages during a method for assembling a filter assembly according to FIG. **1** or **3**.

DETAILED DESCRIPTION

In some embodiments, the filter assembly comprises a filter element with a cylindrical section having a first axial end and a second axial end. The cylindrical section may bed annularly shaped. That the section is a cylindrical section means in particular that it has a circumferential outer surface which has the basic shape of the lateral surface of a cylinder. The cylindrical section may have a central opening which extends axially through the cylindrical section. The cylindrical section may comprise a plastic material or consists of a plastic material.

Expediently, the filter element may comprise a filter screen. The filter screen may be fixed to the cylindrical section. The filter screen may axially overlap the cylindrical section and project beyond the first end of the cylindrical section.

In some embodiments, the filter assembly further comprises a tubular filter housing for receiving the filter element. The filter housing has a sidewall with a radial protrusion for supporting the first axial end of the cylindrical section. When the filter assembly is in its assembled state, the filter element is received in the tubular filter housing such that the first axial end of the cylindrical section is supported by—i.e. in particular in direct mechanical contact with—the shoulder.

In some embodiments, the filter assembly comprises a cap for holding the filter element at its second axial end. The cap encompasses the filter housing along an outer circumference. In particular for holding the filter element at its second axial end, the second axial end of the filter element rests directly against the cap. In this way, axial displacement of the cylindrical section may be blocked in one direction by the shoulder and in the opposite direction by the cap.

In some embodiments, the filter element of the present filter assembly is fixed in both axially directions without deforming the tubular filter housing—e.g. by bending an end of the filter housing radially inwards—after the filter elements has been inserted into the filter housing. In this way, undue axial strain on the filter assembly during manufacture is avoided. As axial forces during bending an end of the filter housing inwards can be as high as 1500 N and more, the filter assembly may thus be less prone to mechanical deformation or even failure during manufacture, installation or operation.

In some embodiments, the filter housing and/or the cap each comprise a metal or an alloy or, preferably, consist of a metal or of an alloy. In this way a high mechanical stability of the filter assembly is achievable.

For example, the fuel injector may comprise a valve needle and a calibration spring for biasing the valve needle towards a closing position. In this case, the filter housing may expediently comprise a spring seat for the calibration spring at its axial end remote from the cap. The filter housing may represent a calibration tube in this case and the filter assembly may be used to set a preload of the calibration spring during assembly of the fuel injection valve. The metallic housing and/or the metallic cap may provide sufficient mechanical resistance for such a calibration function of the filter assembly.

The axial length of the filter housing between the protrusion and the cap may be smaller than the axial length of the cylindrical section of the filter element. In this way, an axial force pressing the cap down onto the filter housing is not transferred to the section of the radial protrusion through sidewalls of the filter housing but rather through the cylindrical section of the filter element. In other words, a form fit connection between the cap and the tubular filter housing can be avoided in this way, which form-fit connection could otherwise unintentionally transfer unduly large axial forces from the cap to the filter housing during assembling the filter assembly or during manufacture of the fuel injection valve when the filter assembly is press fitted into another component of the fuel injection valve by pressing on the cap.

The radial protrusion may be part of a shoulder in the filter housing. The cylindrical section may extend radially inwards further than the shoulder. In this manner, a predetermined distance between the filter screen which axially protrudes beyond the cylindrical section and the filter housing can be guaranteed. Additionally or alternatively, due to the small radial extension of the shoulder, the axial force can be efficiently transferred to a tubular section of the filter housing beyond the shoulder section with a reduced risk of deformation of the filter housing.

For establishing a force-fit connection between the cap and the filter housing with a predetermined friction force during assembling the filter assembly, an inner diameter of the cap may be aligned with an outer diameter of the filter housing. Namely, the cap may be press-fitted to the filter housing. This may provide an easy installation of the cap and a secure hold of the cap on the filter housing. Consequently, the inner diameter of the cap may be aligned with the outer diameter of the filter housing such that the cap is in a force-fit engagement with the filter housing with the predetermined friction when the filter assembly is in its assembled state.

In some embodiments, the filter cap has an open end which axially overlaps the filter housing. It further has an opposite end which is positioned subsequent to the cylindrical section in axial direction from the first axial end towards the second axial end of the cylindrical section. Said opposite end is in particular partially closed. For example, it is comprised by a radially extending lid portion of the cap which is perforated in axial direction by one or more through holes. In this way, fluid can flow through the cap into the central opening of the cylindrical section and further through the filter screen into the filter housing before leaving the filter assembly at an axial end of the filter housing remote from the cap.

In some embodiments, the filter cap comprises a first axial section near its open end and a second axial section near its opposite end wherein a taper is located between said sections in such a way that an inner diameter of the second section is smaller than an inner diameter of the first section. The first section may thus be more easily pushed over the cylindrical section of the filter element during installation of the cap.

In some embodiments, the inner diameter of the second section is aligned with an outer diameter of the cylindrical section of the filter element for resting the filter element laterally against the second section. The alignment can be varied. For instance, a loose fit may be chosen if lateral stabilization is less important while a tight fit may be implemented for holding the filter element, the cap and the filter housing together in an improved manner. In particular, the cap may be configured to fix the position of the second axial end of the cylindrical section in radial direction by means of mechanical interaction with the second section of the cap.

In some embodiments, the filter assembly is adapted to be axially press-fitted with another component of the injector by means of the filter housing. For this purpose, the filter assembly may be configured such that an axial force on the cap is smoothly transferred to a part of the filter housing beyond the cylindrical section of the filter element, e.g. to a part of the filter housing which is positioned in axial direction on the side of the shoulder remote from the cap. This may imply straight walls of the filter housing to as high an extent as possible. Tapers of chamfers, however, may be added as required.

In some embodiments, the cylindrical section is provided with a chamfer at its second axial end. In this way, the risk that an unintended deformation of the cylindrical section occurs at the outer circumference of its upper edge is particularly small.

In some embodiments, the fuel injector comprises a body which is in particular a hollow valve body of the fuel injector and a block which is in particular a pole piece of an electromagnetic actuator of the fuel injector. The block may be positioned inside the body, in particular in the recess of the hollow valve body. It may expediently be positionially fixed relative to the body. The filter assembly may be kept in its position in the fuel injector by friction between the block and the filter housing. In particular, the pole piece has a central opening and the filter assembly is kept in its position by friction with a circumferential surface of the central opening of the pole piece. This may allow easily setting the preload of the calibration spring when the filter assembly has as a spring seat for the calibration spring.

According to a further aspect, a method for assembling the filter assembly is disclosed. The method for assembling the filter assembly according to at least one of the above mentioned embodiments comprises steps of inserting the filter element axially into the filter housing and axially pressing the cap onto the filter housing until the second axial end of the cylindrical section makes contact with the cap.

By using said method, a faster and more cost efficient assembly of the filter assembly may be achieved. By doing away with the risk of physical deformation of the filter housing during the manufacturing process, mechanical stability and integrity of the filter assembly may be maintained.

FIG. **1** shows an example fuel injector **100** for injecting fuel into a combustion engine, in particular in a power train of a motor vehicle. The fuel injector **100** extends along a longitudinal axis **105** and comprises a filter assembly **110** for filtering fuel on its way through the injector **100** between an inlet **115** and a tip **120**. The filter assembly **110** and the fuel injector **100** may share the longitudinal axis **105** as a common longitudinal axis.

In the exemplary embodiment, the fuel injector **100** furthermore comprises a body **125**, a cover **130**, and a block **135**. The block **135** is adapted to receive the filter assembly **110** from an axial direction and the filter assembly **110** may be adapted for press-fitting into the block **135**.

The body **125** may comprise a hollow valve body of the fuel injector. The cover **130** is in particular a fuel inlet tube of the fuel injector which is hydraulically connected to the valve body to enable fluid flow from the inlet **115**, which is in particular comprised by the fuel inlet tube, to the tip **120** which is in particular comprised by the valve body. The block **135** may be a pole piece of an electromagnetic actuator **145** of the fuel injector **100**. The block **135** is positionally fixed with respect to the body **125**.

Some embodiments may include a valve **140** for controlling a flow of fuel through the tip **120** and an actuator **145** for operating the valve **140**. The actuator **145** may comprise a solenoid **150** and an armature **155**. When the solenoid **150** is energized it attracts the armature **155** which is coupled to the valve **140** to displace a valve needle of the valve **140** away from its closing position so that a flow of fuel through the injector **100** is permitted.

The valve needle may be loaded with a calibration spring **160** which pushes the valve needle in a direction opposite to the attraction force of the solenoid **150** and towards the closing position. In the present embodiment, the filter assembly **110** is in contact with the calibration spring **160** on an axial side of the calibration spring **160** remote from the valve needle. The preloading force on calibration spring **160** may be adjusted by changing the axial position of filter assembly **110** with respect to block **135**. Through this, dynamic flow characteristics of the injector **100** may be calibrated. Such calibration may be performed during manufacturing the injector **100**.

The filter assembly **110** may comprise a filter element **165**, a filter housing **170**, and a filter cap **175**. The filter element **165** has a cylindrical section **180**, to which a screen **185** for filtering is attached. The screen **185** may comprise a fine sieve, a fleece, a woven, or non-woven fabric or the like. The cylindrical section **180** may be manufactured from a plastic by means of molding. The screen **185** may be molded to the frame **180** in the same or a successive process. The cylindrical section **180** has an annular shape with a central opening extending through the cylindrical section **180** in axial direction. Thus, the cylindrical section **180** may also be denoted as a cylindrical frame.

The filter housing **170** may be a metal part, for instance manufactured from a metal sheet by deep-drawing. The cap **175** may also comprise a formed sheet metal and it may also be manufactured by deep-drawing. The cap **175** may be press-fitted onto the filter housing **170**. It is preferred that the cap **175** comprises an aperture for permitting a flow of fuel towards the filter element **165**. After passing through the filter element **165**, the fuel may exit through another aperture in the filter housing **170**, near the bottom of filter assembly **110** in FIG. **1**, to flow towards the valve **140**.

FIG. **2** shows the filter assembly **110** during installation in the fuel injector **100** of FIG. **1**. A pressing force **205** is exerted to the filter cap **175** from where it is transferred to the filter housing **170** via the force-fit coupling between the cap **185** and the filter housing **180**. Additionally, the pressing force **205** may be transferred to the filter housing **180** via the cylindrical section **180** of the filter element **165**. The pressing force may lie in the range of 200-1000 N or even more.

Lateral friction between the filter housing **170** and the block **135** creates a resisting force **210** acting in a direction opposite to pressing force **205**. Furthermore, a preloading force **215** of calibration spring **160** acts on the filter housing **170** against pressing force **205**. If the pressing force **205** exceeds the sum of the resisting force **210** and the preloading force **215**, the filter assembly **110** is press-fitted further into block **135** of injector **100**. The press-fitting of filter assembly **110** may be carried out until a flow rate of a fluid through injector **100** has reached a desired value. Then the pressing force **205** may be removed and the filter assembly **110** is kept in its position with respect to block **135** by friction between the block **135** and the filter housing **170**. Thus, the filter housing **170** may also be denoted as a calibration tube.

The filter housing **170** has a shoulder where an inner diameter of the filter housing **170** is reduced downstream the filter cap **175**. The cylindrical section **180** has a first axial end **220** near the shoulder and a second axial end **225** near the cap **175** in FIG. **2**. Generally, the pressing force **205** is

transferred from the filter element **165** to the filter housing **170** via the cylindrical section **180** being in axial contact with the shoulder.

In some embodiments, the cylindrical section **180** includes a chamfer **230** at its second axial end **225** to ensure that a bending radius of the cap **170** between radial and axial surfaces does not get in the way of the cylindrical section **180**.

FIG. **3** shows the filter assembly **110** according to FIGS. **1** and **2**. Details that are not significant for the present invention may differ from the embodiments depicted in FIGS. **1** and **2**.

The filter element **165** is received inside of the filter housing **170**. The first axial end **220** abuts on a protrusion **305** which is, in the present example, implemented as a shoulder in the filter housing **170**. The protrusion **305** may be accomplished in another way like with a diaphragm. A section of the filter housing **170** which lies on an end of the cylindrical section **180** remote from the filter element **165** may be configured for press-fitting into an element—like block **135**—of the injector **100**. In some embodiments, the filter housing **170** has straight walls in this section to as far an extent as possible. However, one or more tapers **310** may be introduced.

In some embodiments, the axial length **315** of cylindrical section **180** of filter element **165** exceeds the axial length **320** of a section of the filter housing **170** that extends from the protrusion **305** towards the second axial end **225** of the cylindrical section **180**. This makes sure that a physical contact between the second axial end **225** of the cylindrical section **180** and an inner side of the cap **175** may be made and a radially extending lid portion of cap **175** remains axially spaced apart from the filter housing **170**.

The cap **175** has an open end **325** for receiving the filter housing **170** and a lid end **330** at the opposite axial side for resting against the cylindrical section **180** on an inner side. In some embodiments, the cap **175** has an aperture **335** at the lid end **330** for permitting flow of fuel into the filter assembly **110**. An inner diameter of cap **175** may be aligned with an outer diameter of the filter housing **170** in the region where it axially overlaps the filter housing **170**. The alignments may be chosen in such a way that frictional forces between the cap **175** and the filter housing **170** prevent the filter housing **170** from sliding out of the cap **175**.

In the present embodiment, the cap **175** comprises a first axial section **340** adjacent to the open end **325** and a second axial section **345** adjacent to the lid end **330**. Between sections **340** and **345** lies a taper **350** and the inner diameter of the first section **340** is wide enough to receive the filter housing **170** while the second section **345** preferably has a smaller diameter. A bending radius of the cap **175** between the radial and axial segments—between the radially extending lid portion and the circumferential sidewall extending from the lid end **330** to the open end **325**—may be sized so the chamfer **230** of the cylindrical section **180** makes no contact with the cap **175** in the bent area.

FIG. **4** shows different stages of a method **400** for assembling the filter assembly **110** according to FIGS. **1** to **3**. In a first step **405**, the filter element **165** is axially inserted into the filter housing **170**. A second step **410** shows the filter element **165** installed at a filter housing **170** in such a way that the first end **220** of cylindrical section **180** abuts on the protrusion **305** of the filter housing **170**.

In a subsequent step **415**, the cap **175** is axially pressed onto the filter housing **170** until an axial surface of cap **175** at lid end **330** makes contact with the second axial end **225** of cylindrical section **180** of filter element **165** as shown in a step **420**. This may require a pressing force which overcomes a frictional force between the first axial section **340** and the filter housing **170** and/or between the second axial section **345** and the cylindrical section **180**. The frictional forces may be determined by an alignment of inner diameters of the cap **175** and outer diameters of the cylindrical section **180** or the housing **170**.

In some embodiments, the pressing continues until the pressing force exceeds a predetermined force which is larger than the sum of the predetermined frictional forces. This serves to ensure that the cylindrical section **180** lies between the lid end **330** of the cap **175** and the protrusion **305** of the filter housing **170** in an axial manner.

What is claimed is:

1. A filter assembly for a fuel injector in a combustion engine, the filter assembly having a longitudinal axis and comprising:

a filter element with a cylindrical section having a first axial end and a second axial end;

a tubular filter housing to receive the filter element;

the tubular filter housing including a radial protrusion supporting the first axial end of the cylindrical section when the filter element is received therein; and

a cap holding the filter element at the second axial end,

the cap encompassing the filter housing along an outer circumference;

wherein

the second axial end rests directly against the cap.

2. A filter assembly according to claim **1**, wherein the cylindrical section includes a chamfer at its second axial end.

3. A filter assembly according to claim **1**, wherein the filter element comprises a filter screen fixed to the cylindrical section.

4. A filter assembly according to claim **1**, wherein the filter housing and the cap comprise a metal.

5. A filter assembly according to claim **1**, wherein an axial length of the filter housing between the protrusion and the cap is smaller than the axial length of the cylindrical section of the filter element.

6. A filter assembly according to claim **1**, wherein an inner diameter of the cap is aligned with an outer diameter of the filter housing such that the cap is in force-fit engagement with the filter housing with a predetermined frictional force.

7. A filter assembly according to claim **1**, wherein the filter cap includes:

an open end axially overlapping the filter housing; and

a partially closed opposite end which is positioned subsequent to the cylindrical section in axial direction from the first axial end towards the second axial end;

a first axial section near the open end;

a second axial section near the opposite end; and

a taper located between said first and second axial sections;

wherein an inner diameter of the second section is smaller than an inner diameter of the first section.

8. A filter assembly according to claim **7**, wherein the inner diameter of the second section is aligned with an outer diameter of the cylindrical section of the filter element such that the filter element rests laterally against the second section.

9. A filter assembly according to claim **1**, wherein the filter assembly is configured to be axially press-fitted with another component of the injector by means of the filter housing.

10. A fuel injector comprising:

a filter element with a cylindrical section having a first axial end and a second axial end opposite along a central longitudinal axis;

a tubular filter housing to receive the filter element;

the tubular filter housing including a radial protrusion supporting the first axial end of the cylindrical section when the filter element is received therein; and

a cap holding the filter element at the second axial end, the cap encompassing the filter housing along an outer circumference;

wherein the second axial end rests directly against the cap;

a hollow valve body;

a block which is a pole piece of an electromagnetic actuator;

wherein the filter assembly is kept in position in the fuel injector by friction between the block and the filter housing.

11. A fuel injector according to claim 10, further comprising:

a valve needle; and

a calibration spring biasing the valve needle towards a closing position;

wherein the filter housing comprises a spring seat for the calibration spring at its axial end remote from the cap.

12. A method for assembling a filter assembly comprising a filter element, a tubular filter housing to receive the filter element, a radial protrusion supporting a first axial end of a cylindrical section of the filter element, and a cap holding the filter element at a second axial end of the cylindrical section, the cap encompassing the filter housing along an outer circumference, the method comprising:

inserting the filter element axially into the filter housing;

axially pressing the cap onto the filter housing until the second axial end of the cylindrical section makes contact with the cap.

13. A method according to claim 12, further comprising pressing the cap until a predetermined pressing force is reached, the predetermined force exceeding a frictional force between the filter cap and the filter housing.

14. A filter assembly according to claim 1, wherein the cylindrical section extends radially inwards further than the radial protrusion of the filter housing.

15. A filter assembly according to claim 1, wherein the cylindrical section comprises a plastic material.

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